SHIFTING BASELINES IN CORAL BLEACHING RESILIENCE

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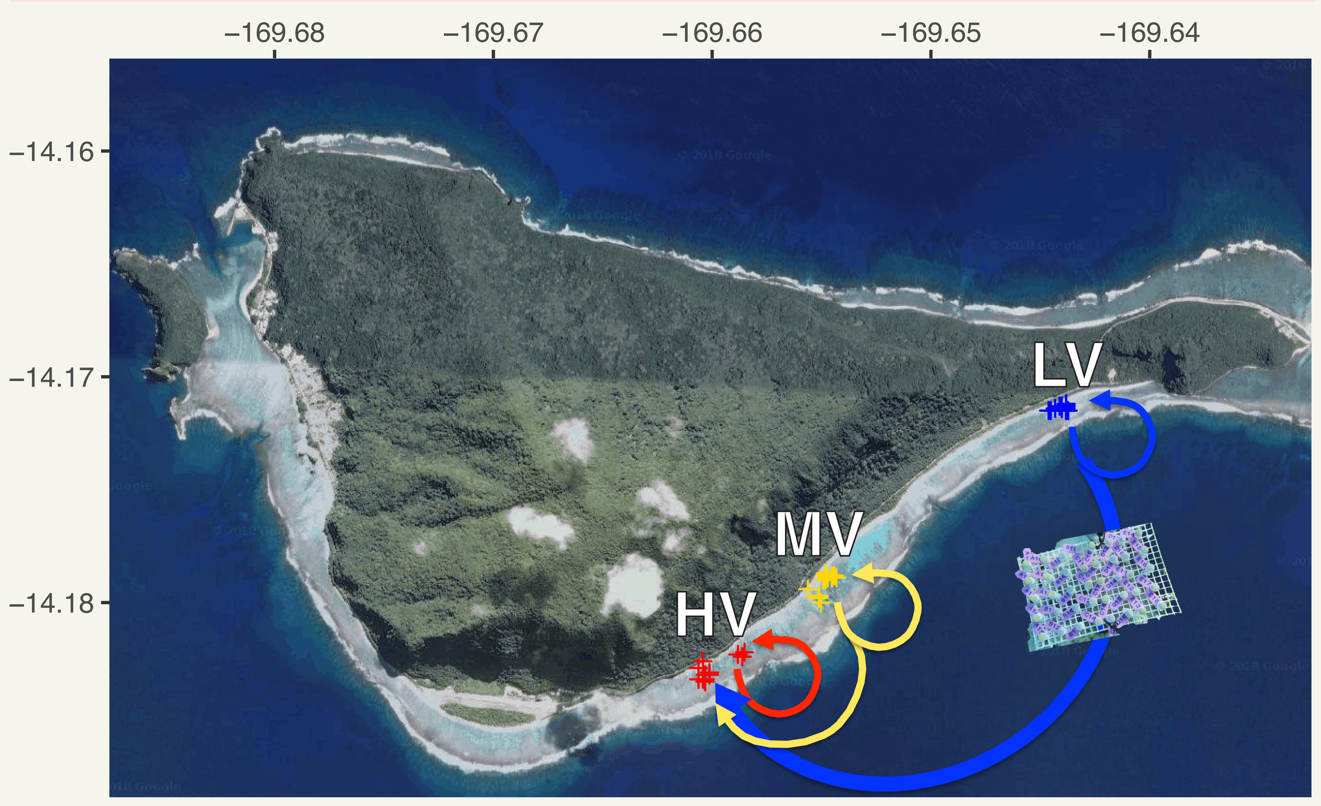
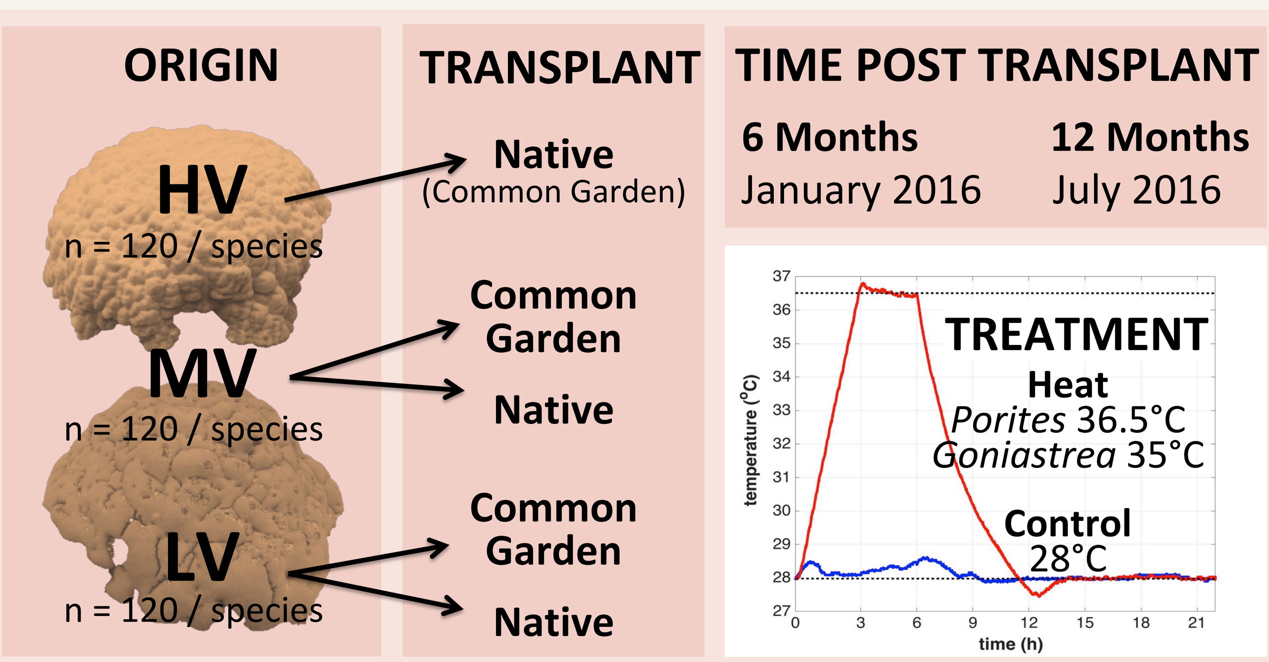
Background

- Coral bleaching events are increasing in frequency, magnitude and duration[1]
- Tropical corals live at/near their upper thermal limits[2]
- Variable thermal reef environments promote increased thermal tolerance[3]
  - These habitats serve as natural laboratories to understand coral stress tolerance
- Branching corals from a highly variable (HV) pool on Ofu Island, American Samoa, have higher bleaching resistance than corals from a moderately variable (MV) pool[3-5], and MV corals increase heat tolerance when moved into the HV pool[5]
  - *Can massive coral species from nearby pools also increase thermal tolerance in the HV pool?*



Map of Ofu Island, American Samoa. Arrows show transplant experiment design within three backreef pools – High Variability (HV; red), Moderate Variability (MV; gold), Less Variability (LV; blue). Crosses denote location of sampled coral colonies (5 per species).

Methods



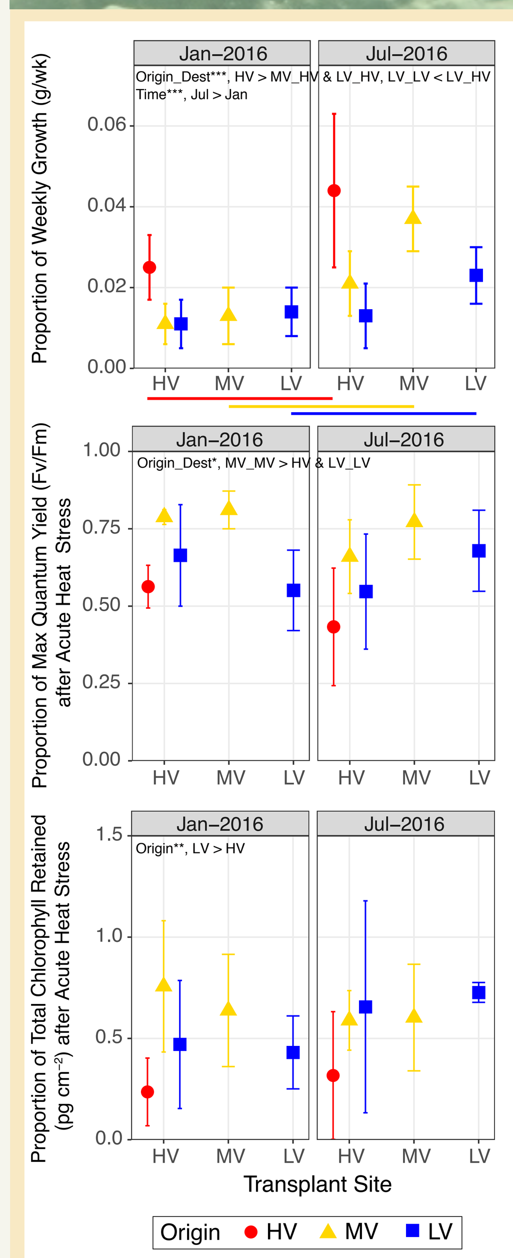
- 22-hr controlled temperature ramp
- Photosynthetic efficiency (Fv/Fm) measured in triplicate at 0 and 22-hrs
- Coral tissue removed and chlorophyll extracted with 90% acetone, measured spectrophotometrically
- Coral genotypes identified using mtDNA markers (NAD5, COI, PCr) and Symbiodiniaceae identified via ITS2 rDNA

Overview

- Coral bleaching resistance is attributed to phenotypic plasticity and adaptation to frequent pulses of sub-lethal water temperatures
- From 2015-2016, we tested whether populations of two massive coral species could increase stress tolerances after transplantation into a backreef pool known to enhance bleaching resistance
- We found evidence of local specialization and limited acclimation potential of massive coral species in conjunction with extreme temperature anomalies in the HV backreef pool

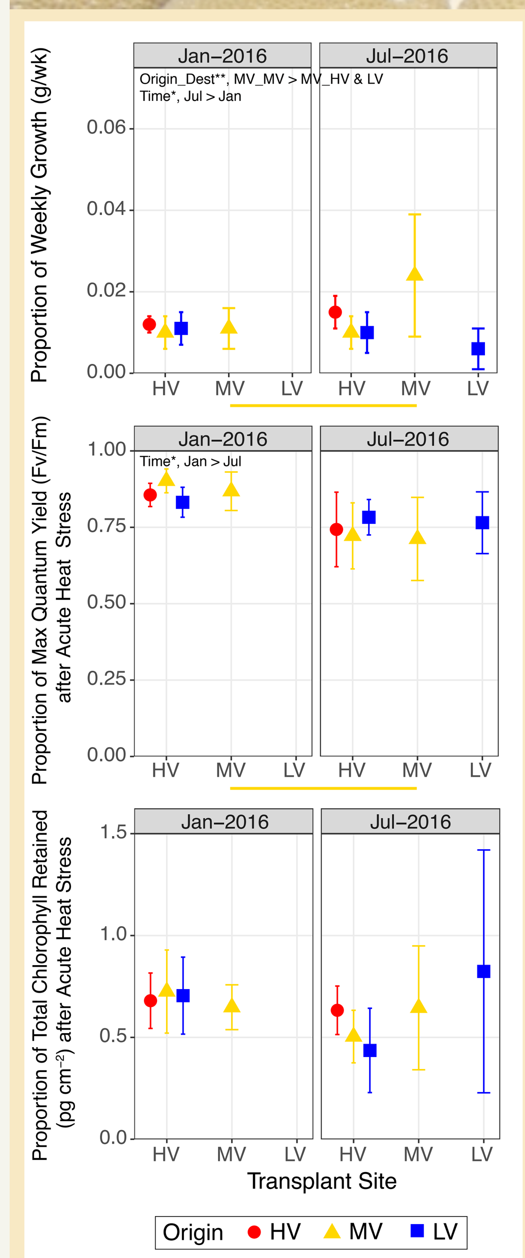
Results

Porites lobata



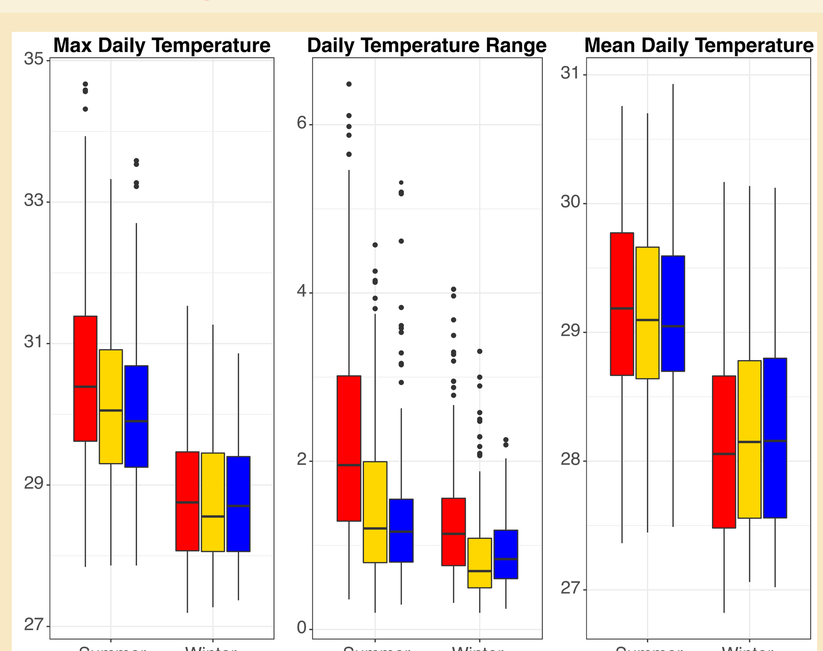
- Growth in HV corals > MV_HV & LV_HV (HV-MV_HV $p < 0.01$, HV-LV_HV $p = 0.001$)
- By July 2016, native > transplant growth (MV_MV-MV_HV $p = 0.001$, LV_LV-LV_HV $p < 0.01$)
- Photosynthetic efficiency in native MV corals > native HV & LV (MV_MV-HV $p < 0.0001$, MV_MV-LV_LV $p < 0.01$)
- Chlorophyll retention in LV corals > HV ($p = 0.001$)
- No effect of heat treatment on MV corals
- All corals harbored *Cladocopium* ITS type C15

Goniastrea retiformis

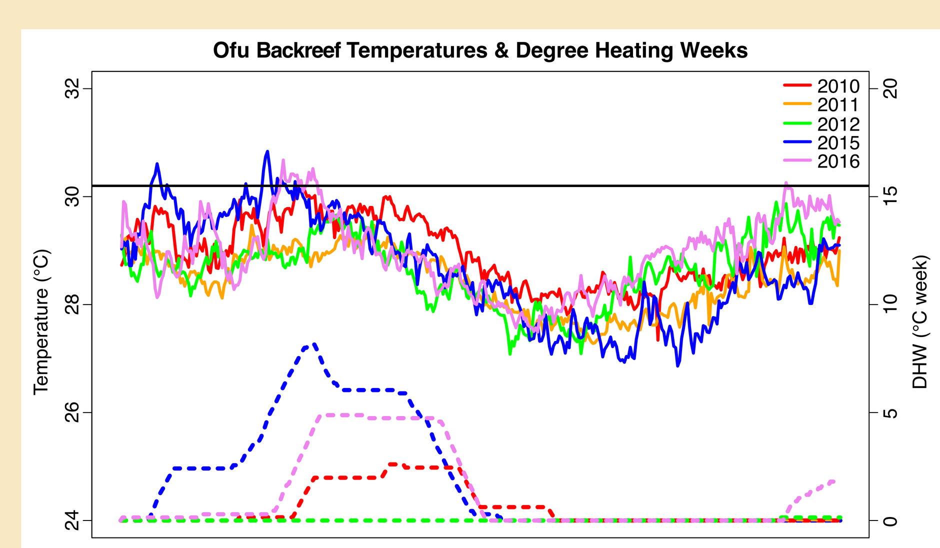


- Growth in native MV corals > MV_HV, LV_HV and LV_LV (HV_MV-MV_HV $p < 0.05$, MV_MV-LV_LV $p < 0.01$, MV_MV-LV_HV $p < 0.05$)
- By July 2016, native MV > transplant growth (MV_MV-MV_HV $p < 0.001$)
- Photosynthetic efficiency of MV corals in January > July ($p < 0.0001$)
- All corals harbored *Cladocopium* ITS type C40, but types C15 and C3 were abundant

Temperature



- Daily thermal maximum in HV pool > MV & LV pool (Tukey's lsmeans for max: HV-MV $p = 0.0103$, HV-LV $p = 0.0043$)
- Daily temperature range in summer > winter (Tukey's lsmeans for DTR: Summer-Winter $p < 0.0001$)



- Sea Surface Temperatures in 2016 > 2011-2012 and 2015 ($p \leq 0.001$)
- Degree Heating Weeks from 2015-2016 > 2010-2012 ($p < 0.001$)

Conclusions

- Coral transplants in the HV pool had reduced growth, decreased photosynthetic efficiency, and greater chlorophyll loss after heat stress
- Corals are specialized to their native thermal environment
- HV corals were more susceptible to acute bleaching stress (*P. lobata* only) than other native backreef corals
  - Illuminates trade-offs between growth (a proxy for fitness) and stress tolerance
- The HV pool's thermal regime appeared to exceed massive coral species' stress tolerance threshold
- This could be the first demonstration of a shifting baseline from increased to decreased resilience in corals residing in high-frequency variable environments
- Species in fluctuating variable environments have evolved the highest tolerance limits and could soon become vulnerable to future climate warming[6]

Ongoing Research

- Full Reciprocal Transplant Experiment between HV and MV *P. lobata* populations to elucidate mechanisms underlying local specialization to Ofu's backreef pools
- Transcriptome-wide sequencing to examine differential gene expression patterns and potential heat-tolerance loci under selection across the three backreef populations of *P. lobata*

References & Acknowledgements

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3. Craig et al. 2001. Coral Reefs 20:185-189.
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5. Palumbi et al. 2014. Science 344:895-898.
6. Stillman 2003. Science 301:65-65.

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